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Environmental Noise Assessment

Wachusett Substation No. 47
National Grid USA
West Boylston, Massachusetts

National Grid

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Table of Contents

Executive Summary

The Wachusett Substation No. 47 (Substation) is located in West Boylston, Massachusetts. Final Substation design will include four 115/69 kV transformers and four 345/115 kV transformers. Currently, one 115/69 kV transformer is installed onsite. Phase I of the project will add three more 115/69 kV transformers and two 345/115 kV transformers. Phase II of the project will add the final two 345/115 kV transformers.

Limited ambient noise data was provided by National Grid for consideration in this environmental noise assessment. However, it is understood that additional ambient noise data may be obtained at a later date. As such, the results of this report may change as a result of the introduction of new information. Nonetheless, this report evaluates the potential impacts regarding noise based on the available information to date.

The potential noise emissions from the Substation have been evaluated based on Phase I and Phase II operation. Based on the evaluation, the increase in the ambient sound levels in the surrounding community due to the operation of the expanded Substation are not expected to result in any significant impacts.

1.0 Introduction

The Wachusett Substation No. 47 (Substation) is located in West Boylston, Massachusetts. The potential noise emissions from the Substation have been evaluated. It is understood that the final design will be achieved in two phases and will ultimately include eight transformers at the site. Specifically, final design will include four 115/69 kV transformers and four 345/115 kV transformers. Currently, one 115/69 kV transformer is installed onsite. Phase I of the project will add three more 115/69 kV transformers and two 345/115 kV transformers. Phase II of the project will add the final two 345/115 kV transformers.

Based on the information provided, there are three residences located near the Substation that have been identified by National Grid as the primary receptors of concern. The nearest residence is approximately 375 feet from the Substation property boundary. All three residences are located on the opposite side of the adjacent railroad tracks (and associated berm) from the Substation.

Ambient noise measurements were taken by National Grid personnel at one of the nearby residences in May, 2003. Specifically, daytime measurements were taken on May 15 and nighttime measurements were taken on May 28. According to the information provided by National Grid, the daytime measurement results ranged from 49 dBA to 51 dBA and the nighttime measurements ranged from 51 dBA to 53 dBA.

The potential facility noise emissions associated with the normal operation of the proposed expanded Substation have been evaluated. Specifically, noise emissions have been evaluated based on two installation phases. The first phase includes operation of six transformers. The second phase includes operation of eight transformers. Future background sound levels were predicted based on the results of the ambient noise measurements provided by National Grid and the substation noise emissions predicted herein.

2.0 Acoustical Terminology

Environmental sound levels are quantified by a variety of parameters and metrics. In order to aid the reader, this section introduces general concepts and terminology related to acoustics and environmental noise.

2.1 Sound Energy Characteristics

Sound energy is physically characterized by amplitude and frequency. Sound amplitude is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 microPa). The reference sound pressure corresponds to the typical threshold of human hearing. Generally, the average listener considers a 1 dB change in a constant broadband noise “imperceptible” and a 3 dB change "just barely perceptible". Similarly, a 5 dB change is generally considered "clearly noticeable" and a 10 dB change is generally considered a doubling (or halving) of the apparent loudness.

Frequency is measured in hertz (Hz), which is the number of cycles per second. The typical human ear can hear frequencies ranging from approximately 20 Hz to 20,000 Hz. Typically, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the low and high frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels, dBA. For reference, the A-weighted sound pressure levels associated with some common noise sources are shown in Table 2-1.

2.2 Human Response to Noise

Noise is often considered unwanted sound. However, human response to noise is complex and is influenced by a variety of acoustic and non-acoustic factors. Acoustic factors generally include the sound's amplitude, duration, spectral content, and fluctuations. Non-acoustic factors typically include the listener's ability to become used to the noise, the listener's attitude towards the noise and the noise source, the listener's view of the necessity of the noise, and the predictability of the noise. As such, response to noise is highly individualized.

Table 2-1

Typical Sound Pressure Levels Associated with Common Noise Sources

Sound Pressure Level (dBA)	Subjective Evaluation	Environment	
		Outdoor	Indoor
140	Deafening	Jet aircraft at 75 ft	
130	Threshold of pain	Jet aircraft takeoff at 300 ft	
120	Threshold of feeling	Elevated train	Rock band concert
110	Extremely Loud	Jet flyover at 1000 ft	Inside propeller plane
100	Very Loud	Motorcycle at 25 ft, auto horn at 10 ft, crowd noise at football game	
90	Very Loud	Propeller plane flyover at 1000 ft, noisy urban street	Full symphony or band, food blender, noisy factory
80	Moderately Loud	Diesel truck (40 mph) at 50 ft	Inside auto at high speed, garbage disposal, dishwasher
70	Loud	B-757 cabin during flight	Close conversation, vacuum cleaner, electric typewriter
60	Moderate	Air-conditioner condenser at 15 ft, near highway traffic	General office
50	Quiet		Private office
40	Quiet	Farm field with light breeze, birdcalls	Soft stereo music in residence
30	Very quiet	Quiet residential neighborhood	Bedroom, average residence (without t.v. and stereo)
20	Very Quiet	Rustling leaves	Quiet theater, whisper
10	Just audible		Human breathing
0	Threshold of hearing		

Source: Adapted from Architectural Acoustics, M. David Egan, 1988 and Architectural Graphic Standards, Ramsey and Sleeper, 1994.

3.0 Ambient Noise Measurements

Ambient noise measurements were conducted by National Grid personnel at one of the nearby residences in May, 2003. Specifically, daytime measurements were taken on May 15 and nighttime measurements were taken on May 28. The ambient noise measurements were taken at a location in the vicinity of the residences located nearest the Substation.

According to the information provided by National Grid, the daytime measurement results at location R2 ranged from 49 dBA to 51 dBA and the nighttime measurement results ranged from 51 dBA to 53 dBA. Daytime measurements were conducted between 9:00 AM and 10:30 AM on May 15. Nighttime measurements were conducted between 11:30 PM and 12:00 AM on May 28. Ambient noise included the influence of light road traffic and birds.

Weather conditions during the daytime measurements included temperatures of approximately 62 degrees F, clear skies, and light winds ranging from three to six miles per hour. Weather conditions during the nighttime measurements included temperatures of approximately 50 degrees F, cloudy skies, and calm winds.

4.0 Environmental Noise Emissions

The environmental noise emissions include the noise emitted by the proposed Substation to the surrounding community. The environmental noise emissions associated with the proposed Substation have been estimated in order to evaluate the potential future noise impacts on the neighboring noise sensitive receptors.

4.1 Noise Modeling Methodology

The environmental noise emissions were modeled using noise prediction software (CadnaA version 3.3.107). The model simulated the outdoor propagation of sound from each noise source and accounted for sound wave divergence, atmospheric and ground sound absorption, sound directivity, and sound attenuation due to interceding barriers and topography. A database was developed which specified the location, octave band sound levels, and sound directivity of each noise source. A receptor grid was specified which covered the entire area of interest. The model calculated the overall A-weighted sound pressure levels within the receptor grid based on the octave band sound level contribution of each noise source. Finally, a noise contour plot was produced based on the overall sound pressure levels within the receptor grid, including specific receptor locations.

4.2 Equipment Noise Sources

Based on the proposed site plan drawing (Drawing H-75986-P, dated 12/16/03), the project will include the addition of seven transformers to the existing Substation site. Based on the information provided, an existing 115/69 kV transformer is currently installed onsite. The proposed project includes the addition of three 115/69 kV transformers and four 345/115 kV transformers. These eight transformers are expected to be the primary noise contributors to the Substation noise emissions. Secondary noise sources are expected to include building wall fans and HVAC units associated with the GIS and control buildings. All of these potenial noise sources were considered in the prediction.

Equipment sound levels were based on a combination of project specific data, available in-house data, and data provided by the Edison Electric Institute (EEI) in the *Electric Power Plant Environmental Noise Guide* (1984).

4.3 Phase I Noise Emissions

The Substation noise emissions were initially modeled based on full load and part load operation of transformer units one through six. Units one through four are understood to be 115/69 kV transformers. Units five and six are understood to be 345/115 kV transformers.

4.3.1 Predicted Noise Emissions from Phase I Operation

The resulting facility noise emissions associated with Phase I are presented in Figure 4-1 as noise contours. Also shown in Figure 4-1 are the nearest noise sensitive receptors previously identified as the primary receptors of concern (shown as R1, R2, and R3). As shown, the sound pressure levels at the nearest noise sensitive receptors due to Phase I operation range from approximately 39 dBA to 42 dBA. It is important to note that these levels represent only the noise associated with the proposed Substation. They do not include the influence of any background noise not associated with the proposed Substation. Specific Substation sound level estimates at the three receptor locations are provided in Table 4-1.

Table 4-1
Phase I
Estimated Substation Noise Emissions

Location	Part Load SPL, dBA	Full Load SPL, dBA
R1	42	42
R2	39	40
R3	40	41

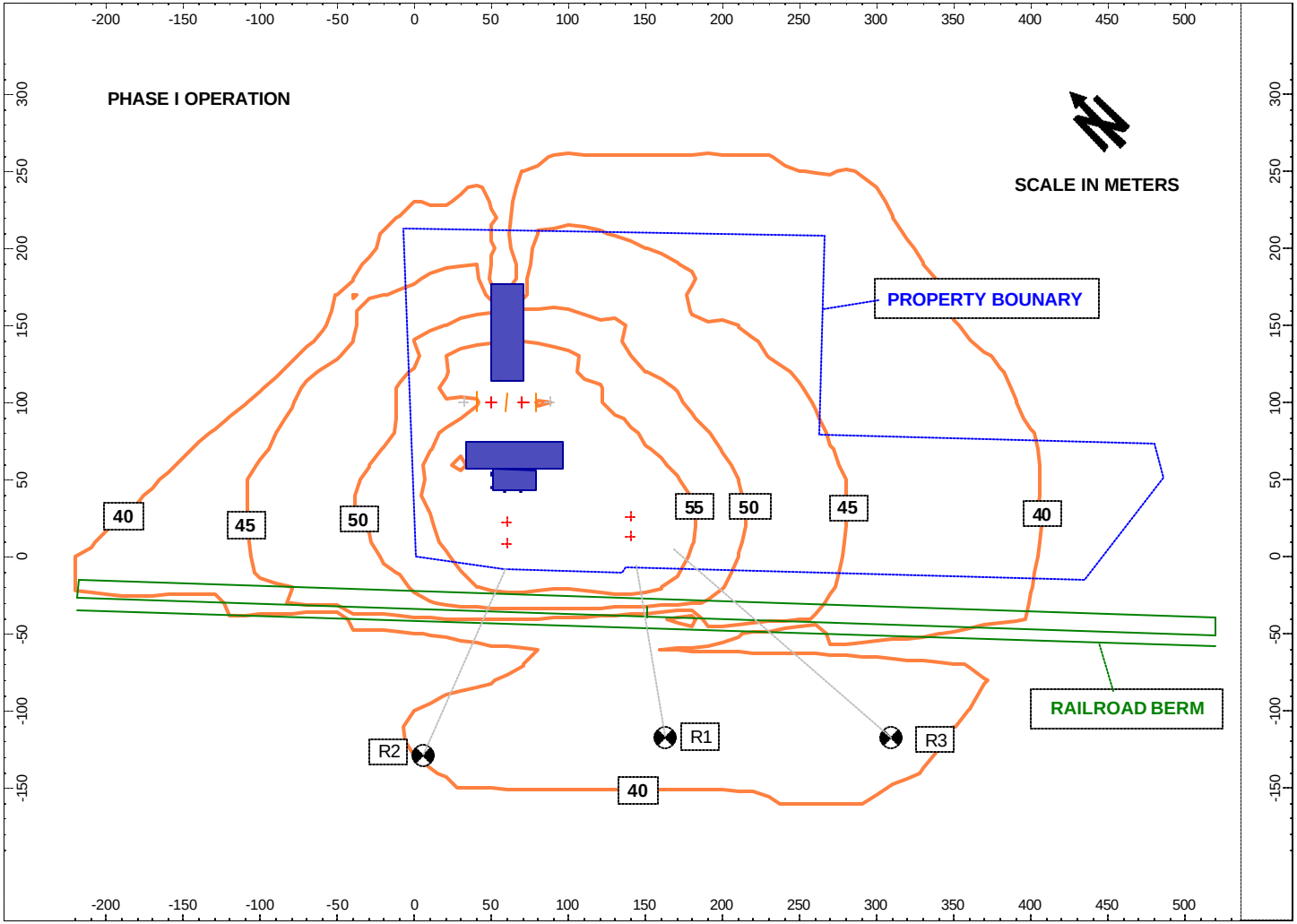

Figure 4-1
Phase I Facility Noise Emissions

4.3.2 Future Background Sound Levels

In order to evaluate the potential noise impacts on the neighboring noise sensitive receptors during Phase I operatoin, the predicted facility sound levels are compared to the measured background sound levels in Table 4-2. As shown, and based on the ambient measurements results, the *increase* in the existing background sound level due to Phase I operation of the Substation is expected to range from 0 to 1 dB at the three nearest receptors. As stated in Section 2.1 of this report, a change of 1 dB is typically considered imperceptible by the average listener.

The results of the ambient noise measurements indicate that the existing sound levels range from 51 dBA to 53 dBA during nighttime hours and 49 dBA to 51 dBA during daytime hours. As such, it is expected that noise from the proposed facility would be consistent with the existing acoustic environment during both daytime and nighttime hours and would not cause a significant disruption to the surrounding community.

Table 4-2
Predicted Future Background Sound Levels During Phase I Operation

Noise Receptor Locations		**Measured Background Sound Level, dBA[3]**		**Predicted Facility Sound Level, dBA[4]**	**Future Background Sound Level w/ Facility, dBA**		**Future Background Sound Level Increase Due to Facility, dBA**	
NML	Description	*min*[1]	*max*[2]		*min*[1]	*max*[2]	*min*[1]	*max*[2]
R1	Residence located approximately 375 feet west-southwest of the substation boundary.	49	53	42	50	53	1	0
R2	Residence located approximately 430 feet northwest of the substation boundary.	49	53	40	50	53	1	0
R3	Residence located approximately 610 feet south-southwest of the substation boundary.	49	53	41	50	53	1	0

NOTES
1. During the quietest measured background noise.
2. During loudest measured background noise.
3. Assumes the measured ambient sound levels are representative of R1, R2, and R3 ambient sound levels.
4. Based on full load operation and max cooling.

4.4 Phase II Noise Emissions

The Substation noise emissions were subsequently modeled based on full load and part load operation of all eight transformers. Units seven and eight are understood to be 345/115 kV transformers.

4.4.1 Predicted Noise Emissions from Phase II Operation

The resulting facility noise emissions associated with Phase II operation are presented in Figure 4-2 as noise contours. Also shown in Figure 4-2 are the nearest noise sensitive receptors. As shown, the sound pressure levels at the nearest noise sensitive receptors due to Phase II operation range from approximately 39 dBA to 43 dBA. As before, these levels represent only the noise associated with the proposed Substation. They do not include the influence of any background noise not associated with the proposed Substation. Specific Substation sound level estimates associated with Phase II operation at the three receptor locations are provided in Table 4-3.

Table 4-3
Phase II
Estimated Substation Noise Emissions

Location	Part Load SPL, dBA	Full Load SPL, dBA
R1	43	43
R2	39	41
R3	40	42

4.4.2 Future Background Sound Levels

In order to evaluate the potential noise impacts on the neighboring noise sensitive receptors during Phase II operation, the predicted facility sound levels are compared to the measured background sound levels in Table 4-4. Similar to Phase I operation, and based on the ambient measurement results, the *increase* in the existing background sound level due to Phase II operation of the Substation is expected to range from 0 to 1 dB at R2. Potential increases related to Phase II operation are likely minimized (relative to Phase I operation) due to interceding barriers onsite (i.e., control buildings) and increased distance between the nearby receptors and Units 7 and 8 compared to Units 1 through 4. As stated in Section 2.1 of this report, a change of 1 dB is typically considered imperceptible by the average listener.

The results of the ambient noise measurements indicate that the existing sound levels range from 51 dBA to 53 dBA during nighttime hours and 49 dBA to 51 dBA during daytime hours. As such, it is expected that noise from the proposed facility would be consistent with the existing acoustic environment during both daytime and nighttime hours. In addition, Substation noise emissions at R2 are consistent for both Phase I and Phase II of the proposed project. As such, it can be concluded that background noise (i.e., non-Substation noise) has a greater influence on the ambient sound level at R2 than the proposed Substation, based on the ambient noise measurements and the noise modeling results.

Table 4-4
Predicted Future Background Sound Levels During Phase II Operation

Noise Receptor Locations		**Measured Background Sound Level, dBA[3]**		**Predicted Facility Sound Level, dBA[4]**	**Future Background Sound Level w/ Facility, dBA**		**Future Background Sound Level Increase Due to Facility, dBA**	
NML	Description	*min*[1]	*max*[2]		*min*[1]	*max*[2]	*min*[1]	*max*[2]
1	Residence located approximately 375 feet west-southwest of the substation boundary.	49	53	43	50	53	1	0
2	Residence located approximately 430 feet northwest of the substation boundary.	49	53	41	50	53	1	0
3	Residence located approximately 610 feet south-southwest of the substation boundary.	49	53	42	50	53	1	0

NOTES
1. During the quietest measured background noise.
2. During loudest measured background noise.
3. Assumes the measured ambient sound levels are representative of R1, R2, and R3 ambient sound levels.
4. Based on full load operation and max cooling.

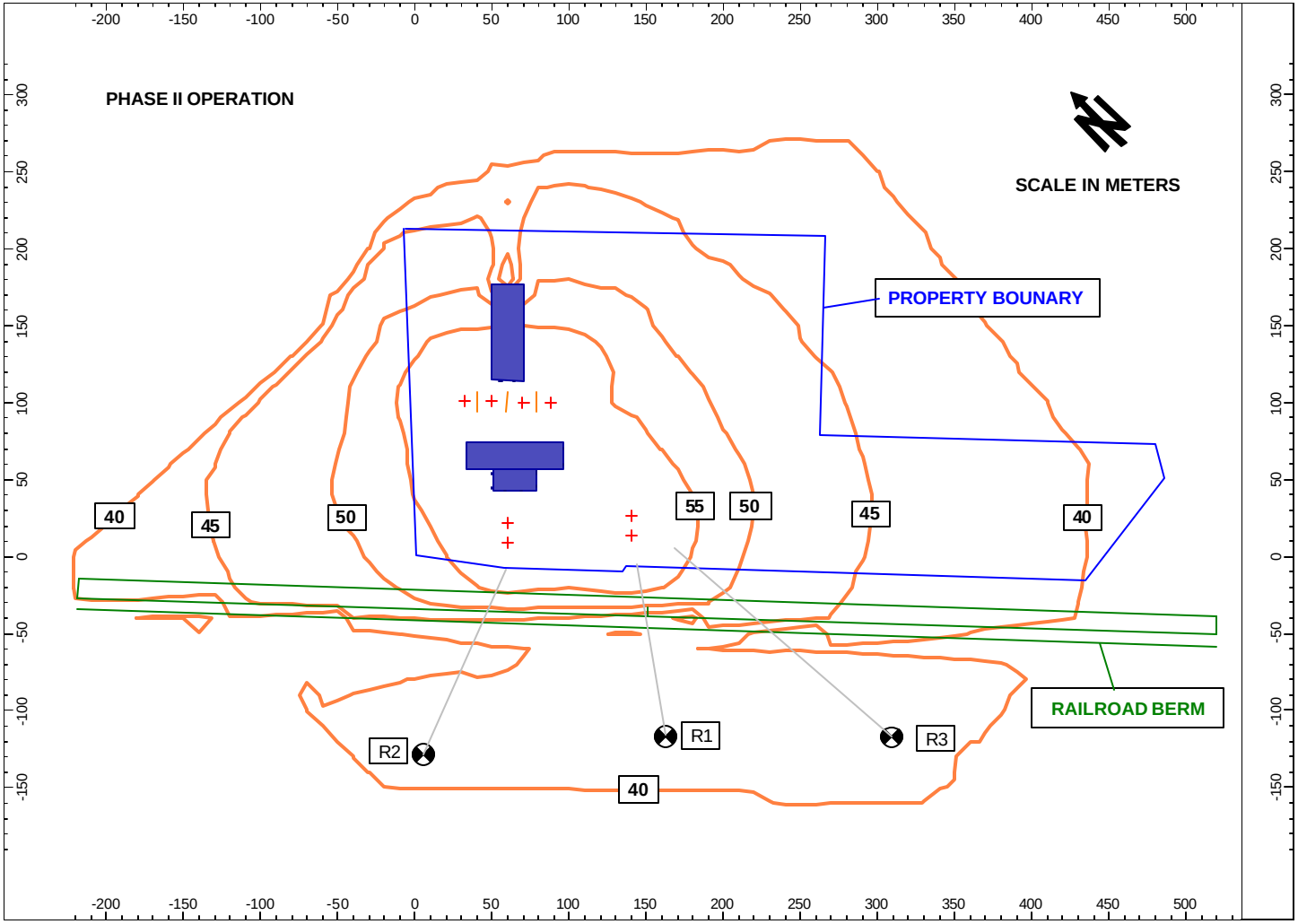

Figure 4-2
Phase II Facility Noise Emissions

4.5 Prominent Discrete Tones

In addition to the overall sound level, discrete tones (audible hums) are often a concern with transformer installations. As defined in ANSI S1.13, a discrete tone is classified as being prominent if the sound pressure level of the critical band containing the tone (typically 60 Hz and 120 Hz in transformers) exceeds the average sound pressure level of the adjacent bands by 7 dB. This is typically evaluated by narrow band or one-third-octave band analysis. The ambient sound level measurements conducted by National Grid did not include one-third octave or narrow band analysis, therefore the existence of discrete tones associated with the existing transformer is unknown at this time. Additionally, similar one-third octave or narrow band sound levels were not available from the transformer manufacturer. Nonetheless, it is anticipated that the transformers will be specified to minimize the discrete tones and therefore minimize the potential impacts to the neighboring noise sensitive receptors. However, the hum of the transformers may be audible at times, particularly during simultaneous full load operation of all of the transformers.

5.0 Conclusions

The Wachusett Substation No. 47 is located in West Boylston, Massachusetts. The potential Substation noise emissions have been evaluated based on available information, including the proposed site plan, transformer sound level specifications, and the location of nearby receptors.

The project is expected to include two phases. Phase I will include installing five transformers and relocating the existing transformer. Phase II will include installing the final two transformers. As such, final project development will result in a total of eight transformers being located at Wachusett Substation No. 47.

Substation noise emissions associated with Phase I operation are estimated to range from 39 to 42 dBA at the nearest receptor locations. Similarly, Phase II operation is estimated to result in substation noise emissions that range from 39 to 43 dBA at the nearest receptors.

Finally, the maximum increase in the future background sound level at the nearest residences is expected to be approximately 1 dB. The increase in the future background sound levels is based on the limited ambient data provided and assumes the ambient data is representative of all three residences (R1, R2, and R3). Typically, increases in sound levels of 3 dB or less are considered to be imperceptible to average listeners. Therefore, the Substation expansion project is not expected to have a significant impact on the residents at R2. Moreover, if the measured ambient noise levels taken at R2 are indicative of ambient sound levels at R1 and R3, then significant impacts at these two locations would not be expected to occur as a result of the proposed Substation expansion.